Astro 534, Stellar Structure and Evolution

Due April 1

The basis of this homework will be real stellar evolutionary models, which you will compute for yourself via a web-based interface. Go to

`http://www.astro.wisc.edu/~townsend/static.php?ref=ez-web`

There you will find a web interface to Bill Paxton's *Evolve ZAMS* code. You can enter a mass, a metallicity, a maximum age (best to set this number to something large, like 2E10) and a maximum number of steps (such as 1000), and the program will evolve a star for you using the Henyey method. (Sometimes the evolution is followed through to the tip of the red giant branch, and sometimes it goes further. I haven't figured out the pattern, so you'll just have to look over the results of each run.) The program automatically creates a summary file (containing global properties such as effective temperture, luminosity, core mass, etc.), which you can download using a link that will be e-mailed to you. If you desire detailed information about each individual model (such as its the radius, pressure, temperature, etc., at each mass point), this can also be downloaded by checking a box.

1. First, evolve a $5M_{\odot}$ star with solar metallicity. Now consider a star cluster with an age of $\sim 10^8$ years. Assume that all the stars in this cluster with masses below $5M_{\odot}$ will be sitting on the main sequence, while all stars with masses greater than $5M_{\odot}$ will have already completed their evolution. So, to an excellent approximation, all the non-main sequence stars of this cluster will have (initial) masses of $5M_{\odot}$.

a) Use the information contained in your $5M_{\odot}$ evolutionary track to estimate how may stars you would expect to find in the "Hertzprung Gap" (i.e., the region between the main sequence and the red giant branch?) compared to the number of red giant branch stars?

b) Now make a plot of the luminosity function of the cluster, i.e., the relative number of stars you would expect to see at a given (log) luminosity. Point out the "interesting" features of this plot.

2. Examine the internal structure of a $3M_{\odot}$ star when it is at the base of the giant branch. How much more (or less) energy is the star creating with nuclear reactions than with gravitational contraction. (Note that since the stellar core is contracting while its outside is expanding, the star is both creating and expending gravitational energy. Just consider the gravitational energy it is creating.)

3. The Tip of the Red Giant Branch (TRGB) is frequently used as a distance indicator in extragalactic astronomy. Make a plot showing how the TRGB varies with population age. What happens if you drop the metallicity down to, say, 1/20th solar? How good a distance indicator is the TRGB, and what galaxies can it be applied to? Spend a few minutes thinking about this question before you answer.

4. Examine how the radius of a star changes with time. Compare the results of a $1\,M_{\odot}$, $2\,M_{\odot}$, $3\,M_{\odot}$, and $5\,M_{\odot}$, stars. How large to these stars get (in astronomical units). Suppose you find a white dwarf orbiting a main sequence star with a separation of N A.U. What can you conclude about the history of the system as a function of N?

5. The stellar evolutionary tracks that you have created obviously contain *a lot* more information that what I've asked about above. Choose a parameter (or set of parameters) that interests *you.* (Some possibilities might be the size of a convective core, the depth of the convective layer, or the relative amount of energy produced by the different energy generating mechanisms.) Write a short discussion about the behavior of the parameter.